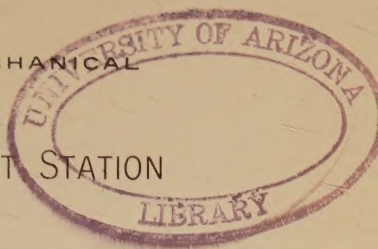


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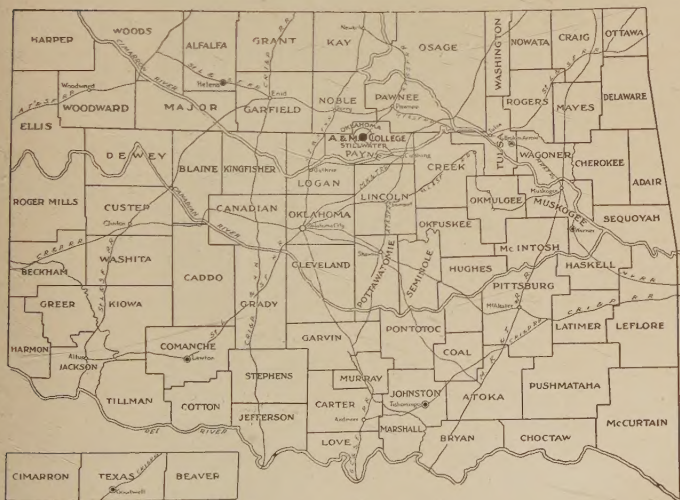


CIRCULAR No. 33

JUNE, 1914

FOUR CHEAP SILOS

BY C. I. BRAY AND D. R. FORRESTER
DEPARTMENT OF ANIMAL HUSBANDRY



LOCATION OF THE A. & M. COLLEGE AND THE SIX SCHOOLS OF AGRICULTURE

STILLWATER, OKLAHOMA

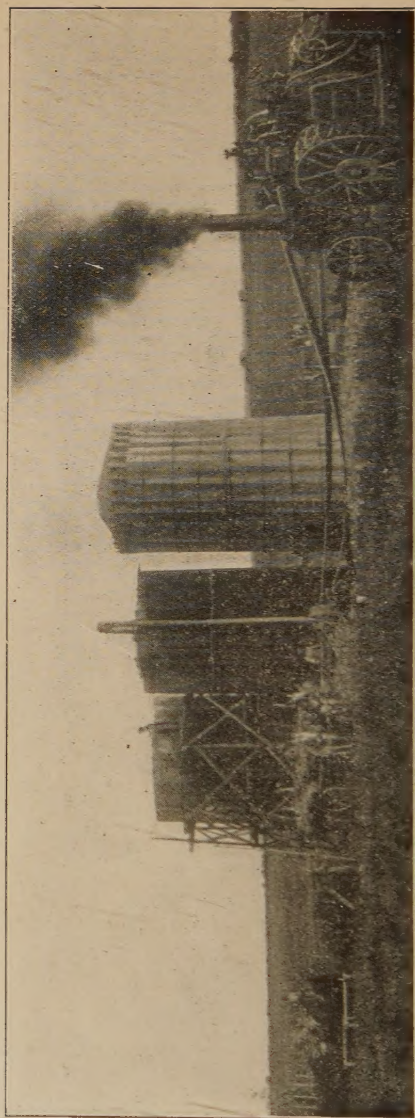


Figure 1.—Homemade Stave Silos on A. and M. College Farm

FOUR CHEAP SILOS

BY C. I. BRAY AND D. R. FORRESTER

This circular is being published in advance of the large silo bulletin the College is getting out in order to supply information regarding some of the cheap silos about which we receive inquiries.

A permanent type of silo is undoubtedly the best investment for the man with means, a farm of his own and a permanent location for his buildings. There are many farmers, however, who need silos who are either renters or who for other reasons cannot afford to build a good substantial silo. It is for the sake of such farmers that this circular is being published. It is intended as a supplement to the various silo bulletins and circulars now being sent out by the College, consequently it includes little duplicate matter.

REQUIREMENTS OF THE SILO

There is no best silo. If a silo fulfills the following conditions it will keep silage perfectly. Permanent silos are, of course, more desirable, but are correspondingly expensive.

1. The walls of the silo must be airtight.
2. They must be perpendicular and smooth.
3. They must be strong and rigid.
4. The silo should have a height of about two and one-half times its diameter.

Capacity of Round Silos in Tons

The following table gives the standard capacities of round silos and is correct for heavy silage of good quality, silos filled again after settling. For ordinary Oklahoma silage, somewhat dry, take two-thirds to three-fourths of amounts stated:

Inside Height of Silo	Diameter of Silo							
	8 Ft.	10 Ft.	12 Ft.	14 Ft.	16 Ft.	18 Ft.	20 Ft.	22 Ft.
20 feet	17	26	38	51	67			
22 feet	19	30	43	59	77			
24 feet	22	34	49	67	86	110		
26 feet	24	38	55	75	97	123	152	
28 feet	27	42	61	83	109	137	169	205
30 feet	30	47	67	91	119	151	187	226
32 feet	33	51	74	100	131	166	205	248
34 feet	36	56	80	109	143	181	224	271
36 feet	39	61	87	118	155	196	243	293
40 feet	45	70	101	138	180	228	282	340

I—THE HOMEMADE 2x6 STAVE SILO

The homemade wood-stave silo, as used on the A. and M. College farm, is very cheap and efficient, costing only about \$100.00 for seventy to eighty tons capacity. (See Figure 1.)

Material Needed

- 100 pieces of 2x6, common pine, 24 feet long, dressed edges
- 6 pieces of 2x4, 24 feet long
- 384 feet of $\frac{5}{8}$ -inch iron rods
- 24 $\frac{3}{4}$ -inch tank lugs
- 4 pounds of $\frac{5}{8}$ -inch hexagonal nuts
- 100 feet of 3-inch cypress bats.

The lumber in 24-foot length staves will make a silo 14 feet 9 inches in diameter by 24 feet high, holding approximately seventy-five tons of silage. Have the $\frac{5}{8}$ -inch iron rods cut into 16-foot lengths and threaded 6 inches at each end. Bend to the right circumference of your silo. This will make eight iron hoops, each hoop in three pieces, and joined together with tank lugs. Level the ground on which the silo will stand, and by means of a small sweep, 7 feet $4\frac{1}{2}$ inches from center to circumference, lay off an exact circle for the bottom of the staves so that your circumference will be perfect.

Directions for Setting Up

Door Frame.—The doorway is a continuous opening from top to bottom, made of 4x6's (spiking 2x6's together). Pick out straight and sound pieces for the door frame and fasten together. Lay one side piece on top of the other and bore 1-inch holes through both pieces 2 inches from the inner edge. These are for the hoops to go through. Bore the first hole 12 inches from the bottom, the next one 2 feet above the first, the third 2 feet above the second, the fourth $2\frac{1}{2}$ feet above that, the fifth 3 feet above the fourth, the sixth $3\frac{1}{2}$ feet above the fifth, the seventh 4 feet above that, and the eighth and last one 5 feet above the seventh and 1 foot below the top of the silo. These holes will allow the continuous iron hoops to pass through the door frame, and these side pieces may now be fastened together in ladder form 2 feet apart. Spike a piece of 2x6 across the ends at top and bottom, and nail pieces of 1x4 across the front for ladder rungs, spacing them so that they will come in front of the hoops. Extra steps are put on near the top where the hoops are wide apart. Erect the door frame in place and anchor it firmly by means of temporary braces.

The six pieces of 2x4's (24-foot-lengths) should have 1-inch holes bored to allow the hoops to pass through, and these holes must be spaced the same as the ones in the door frame. The 2x4's should be set up around the circumference of the silo and braced so that they

will be approximately seven feet apart and will fit edgewise into the wall of the silo. Be careful to bore the holes so that the inside edge of the 2x4 will come flush with the inside wall when the staves are set in place. The iron hoops are then placed in position through the holes in the door frame and the 2x4 ribs and joined together by the rings.

After the door frame and the 2x4's are up and braced, and the rods put through the holes, as described above, this skeleton framework is used in place of an outside scaffold. This method was not used in putting up the first silo. Put staves across to ride on the rods, making one footboard about seven feet from the ground, one half way up, and one near the top. Bend the hoops to the right curve before putting them through the holes. Beginning at the doorway, set up the first 2x6 stave and by means of small nails and a cleat tack this stave to the door frame. Laths soaked in water make good cleats for this work. Continue putting up the staves, being sure that they are plumb, and that they follow the right circumference, tacking each stave to the preceding one. When the first 2x4 rib is reached, jam this rib up firmly against the last stave, and tack a long brace from the door frame to this rib. This makes the wall strong, and as each section is filled in these braces should be placed from each rib to the door frame. As the wall is nearly completed it may be necessary to use a ladder or a light scaffold on the inside to put in the last staves. As the last stave is placed in position the hoops should be tightened gradually from bottom to top and the cleats on the inside knocked loose. The door is closed with short sections of the 2x6's as the silo is filled, using putty or white lead or clay between the boards. This silo is built right on the ground without foundation or anchoring and is taken down each summer as soon as empty and stored away. It is not much trouble to set up again in the fall.

Where the above system of erecting is not followed, the silo may be put up by means of scaffolding, as any other stave silo. The door frame is set up first, as before, and hoops put in place and held up by the scaffolding. Only the two top hoops and the two bottom hoops need be put in place at this time, having first bent them to the right shape on the ground.

The 2x6 staves can be readily put in place then and held together by toe-nailing the first ones on each side of the door frame. Then, at the upper and lower parts of the silo on the inside, tack barrel staves or lath or other thin lumber around to hold the staves together. On the outside the driving of 12-penny nails in each stave at one of the upper and lower hoops and hooking the nails over the hoops will help hold the staves in place until the hoops are tightened. If a man is kept on the inside to tap the staves into place while the hoops are being tightened, a good job can be made and the walls will be tight. The silo must be kept in an exact circle and the staves plumb. Two or three diagonal braces will keep the silo from twisting.

II—THE FLOORING SILO WITH WOODEN HOOPS

The flooring silo with wooden hoops is one of the very cheapest silos, and can be profitably used on farms where there is only a small herd of livestock, such as five or six milk cows and a team of horses. A silo 7 feet in diameter and 20 feet high will hold fifteen tons of silage. This is a very small silo, and ordinarily it is not profitable to erect one of such dimensions. However, with such cheap material this size of silo may prove profitable.

Materials for Wood-Hoop Silo 7x20, Capacity 15 Tons

530 feet of 6-inch hard pine flooring @ \$30.00 per M.....	\$ 15.90
220 feet lapsiding for ten hoops @ \$30.00 per M.....	6.60
Nails	1.00
Total	\$ 23.50

Bill of Lumber for 16x24-Foot Silo, Capacity 86 Tons

1440 feet 6-inch hard pine flooring @ \$30.00 per M.....	\$ 43.20
600 feet ½x4-inch lumber for hoops @ \$30.00 per M.....	18.00
Nails	2.00
Total	\$ 63.20

The total cost of this first-mentioned silo, outside of labor, will be about \$1.60 per ton capacity. Two men can build it in one and a half days.

It is not advisable to build large silos of this type, since the length of flooring is not enough to get sufficient height for a large diameter silo. Twenty or twenty-four feet will probably be the greatest length of flooring on the market. Fourteen feet is about the maximum diameter for a silo of this height. By digging down in the ground from four to six feet and building a concrete foundation wall, a depth of thirty feet can be secured, which will be sufficient for a silo 16 feet in diameter. The cost of excavating six feet, with the cost of cement, would make the total cost of this silo about one hundred dollars. A silo of this size will hold 120 tons and will not cost over one dollar per ton capacity, and possibly as low as seventy-five cents per ton capacity.

How to Build a Wooden-Hoop Silo

To build this silo, first make three-ply or four-ply hoops of wood. Where native lumber cannot be had, good batting or cypress lapsiding may be used, or any ½x6-inch stuff will do. The best way to make these hoops is to draw an exact circle of the right diameter on a barn floor or good, hard ground. If on a barn floor, nail blocks firmly on the inside of the circle, four inches high and eighteen inches

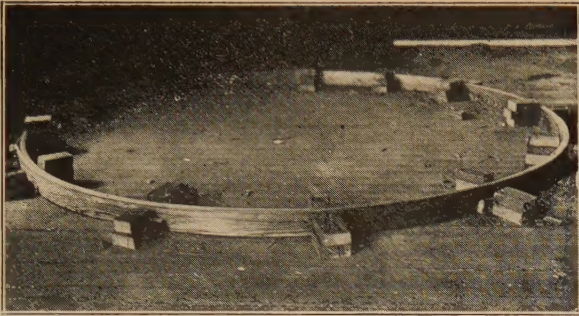


Figure 2—Wooden hoop for silo in process of construction. Note double circle of blocks, with wedges driven between hoop and outside blocks

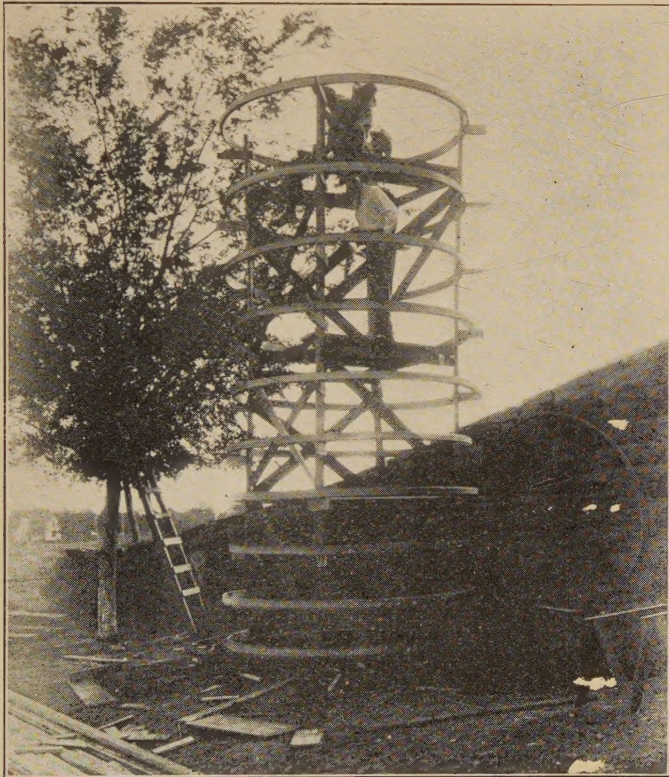


Figure 3—Model wooden-hoop silo in process of construction. Scaffolding up and hoops in place

apart, and nail other blocks two inches outside of these. If on the ground, drive good, square stakes instead of blocks. The hoops are made by placing the lumber between the two rows of blocks, wedging down firmly against the inside blocks, and nailing with 8-penny galvanized nails. (See Figure 2.) In setting up the silo the hoops are all placed one on top of the other on the foundation, then a four-legged scaffold is built on the inside as high as the proposed height of the silo. The legs of the scaffold are kept about one foot from the edge of the silo. Staging should be placed about eight feet apart. Beginning at the bottom, mark off on the up-rights of the scaffold the place for the bottom hoop, making sure it is the same height on each upright. Then from this point measure eighteen inches higher for the next hoop and mark the place, twenty inches to the next, twenty-two inches to the next, and so on to the top. Draw the top hoop to the required height and hold in place by

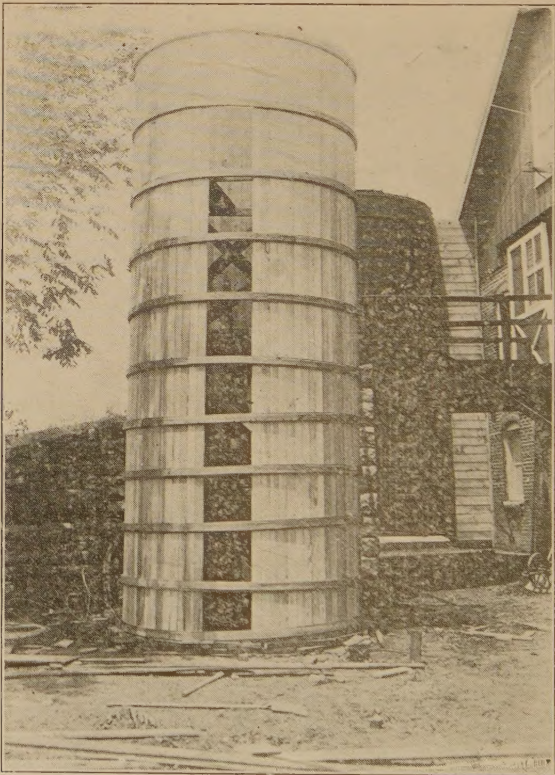


Figure 4—Model wooden-hoop flooring silo at A. and M. College beef cattle barn. Lumber donated by Spurrier Lumber Company, Stillwater. Size 8x24 feet, capacity 17 tons; cost \$23.00

nailing on bracket arms to every scaffold leg where marked, letting the hoop lie loosely on top of these brackets. Continue in the same manner until each hoop is in place. (See Figure 3.) Then begin putting on the hard pine flooring inside, commencing at one edge of where the doorway is to be. In putting on this lining, keep the groove ends of the board ahead. Double nail every other board on each hoop and single nail the others. Use 8 or 10-penny galvanized nails for this purpose. Drive the boards up close and draw tight, thumbing the hoops as you advance. Leave an opening for a continuous doorway about twenty inches wide. No door frame is needed. Simply cut off pieces of flooring 26 or 28 inches long and nail two or three pieces together so as to make narrow doors 7 to 10 inches wide and 26 to 28 inches long. Lay these one above the other across the opening as filling advances. (See Figure 4.)

One of the most important things to watch in building is to have the hoops the right distance apart and the wall plumb while the lining is being put on. Professor A. S. Neal of the Kansas State Agricultural College recommends that the hoops be treated with creosote or some wood preservative, and that the bottom hoop be bedded in a concrete foundation, building up the cement on the outside of the hoop. It is better to have a number of spikes driven through the hoops into the cement. These silos are good for at least eight years.

The Lined Flooring Silo

A more permanent type of wood-hoop silo may be made. Hoops are made of $\frac{1}{2}$ -inch stuff, as in the silo just described, but four thicknesses are used instead of three. One-inch flooring is nailed on perpendicularly as before, but by breaking joints at the third and ninth hoops the silo may be made 30 feet high instead of 24 feet. A lining of building paper, plain or tarred, is next put in, and then one thickness of half-inch lumber, which may be nailed on round and round or up and down as before. The latter is easier to put on, but the other way adds much to the strength of the silo. Green hardwood is recommended for making the hoops, but is not essential. With a good concrete foundation and sufficient anchoring at top and bottom there is no reason why this silo should not prove reliable and permanent. The door in this silo may be continuous or only in each alternate space between hoops.

Wood silos should be well braced and anchored if they are left standing empty during the summer. In both the homemade stave silos and the flooring silo a strong wooden or iron hoop should be put at the top of the silo on the inside. This keeps the staves from blowing in and makes a good attachment for guywires. At least three guywires should be run from the top of a silo to some nearby trees or posts at equal distances around the silo. A log buried in the ground will do where there is nothing else to fasten to. Two strands

of No. 9 or heavier wire may be used. Holes should be bored through the top of the silo in such a way that the guywires will go around and through the inner hoop at the top. After attaching to the anchor at the bottom the wires may be twisted together until tight.

III—PIT SILOS

Pit silos are cheaply constructed and require little attention after building. They can be filled with small machinery; the ensilage never freezes in them, and if well constructed they are nearer everlasting than any other silo. The greatest objection to the pit silo is the extra labor required in removing the silage. Other objections of minor importance are: The liability of stock falling in; danger of carbon dioxide gas forming; and the spoiling of the silage in wet seasons from seepage.

About twice as much time is required to remove silage from a pit

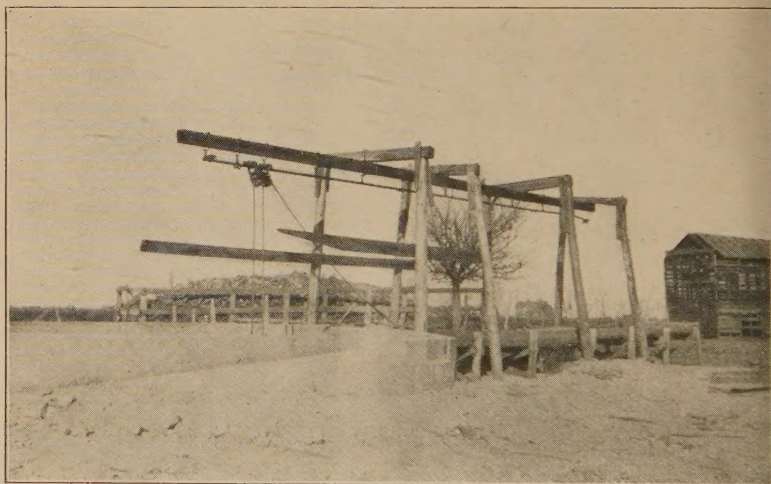


Figure 5—Pit silo with hay carrier track to feed troughs

silo as from an ordinary silo, but counting time at 20 cents an hour, the extra cost is only about \$11.00 or \$12.00 per year for a 100-ton silo, or less than the increased interest on a \$400.00 silo. This estimate of the increased expense in removing the ensilage is also offset by the fact that much cheaper machinery can be used in filling the pit silo.

To prevent stock from falling in the pit silo, the silo walls are usually built up about four or five feet above ground. Suffocation from carbonic acid gas in pit silos, while possible, has, perhaps, been over-emphasized. The formation of gas in quantities large enough to

dangerous ceases in about ten days after filling the silo. A few bales of fodder dropped in will stir up the air so as to render it safe to enter the silo. Gas can be detected by lowering a lighted lantern into the pit. If gas is present the light will go out. Where filling has been only partly completed and then discontinued for a few days, filling should be started again for five or ten minutes before any one goes into the silo. The pit silo should never be built where the water level is not some ten feet or more below the desired depth of the silo. This is one reason why the pit silo is more popular in the semi-arid west than elsewhere. There are occasional rainy seasons when seepage water may give trouble. Thus far, however, we have not heard of much silage being destroyed in this way.

To build a pit silo, first lay out a circle on the ground the desired size of the silo, and outside of this circle dig a trench, which should be about two feet deep and about eight inches wide. (See

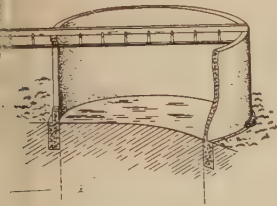


Figure 6



Figure 8

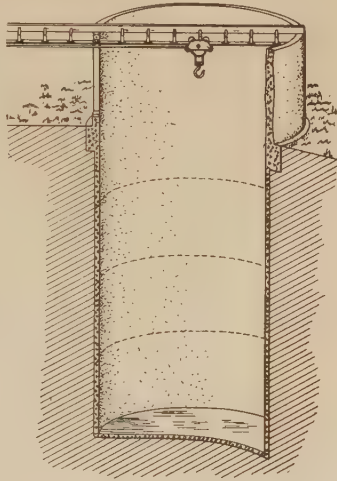


Figure 7

Figure 6 shows the beginning of a pit silo, with concrete collar and wall, built up 5 feet above it. Carrier track in place to carry away earth, also to take out silage. Figure 7—Section of completed, plastered pit silo showing sections as dug and plastered. Figure 8 shows a barrel as arranged for raising earth. On removing the end-gate rod the barrel dumps itself. (Courtesy of Nebraska Experiment Station)

Figure 6.) The inside wall of the trench should be smooth and perpendicular. Fill the trench with a concrete mixture of one part cement and five parts sand or gravel, well mixed and very wet. Old iron rods or old barbed wire can be used for reinforcing to keep the rim from cracking. When this concrete rim has set, go inside and excavate to a depth of about six feet below the rim. Keep the walls plumb and smooth so that it will not require too much mortar for plastering.

A good way to keep the walls smooth is to drill a perpendicular hole in the center of the silo and set a gas pipe in this hole to use as a pivot. If a long gas pipe is not at hand, a shorter bar may be used if care is taken to keep it plumb. Bore a hole near the end of a 2x4 scantling and place it over the gas pipe. Saw the other end off so its length from the gas pipe will be the same as the radius of your silo. Bolt some heavy blade on this end. For this purpose an old plowshare is good. The walls can be trimmed perfectly smooth and perpendicular with this device, but with care the walls can be kept straight without it.

The trimming should be kept well up with the digging to prevent throwing the dirt out from a greater depth. After the silo is completed the collar at the top should be extended at least one foot above ground level to prevent surface water from running into the silo. This may be built up later with bricks, concrete blocks or solid concrete, as in Figures 5 and 6, to a height of four or five feet above the level of the ground. If the walls are made higher than this it will be difficult to take the silage out with a block and tackle. A lot of the dirt taken out of the pit may be graded up around the silo so as to bring the ground level up three or four feet.

Plastering

For best results, the walls of a pit silo should be plastered to prevent caving in. Pit silos can be used without plastering, but are not satisfactory after one year's use. The plaster should be made of one part cement and two and a half parts sand. Before it is put on the wall must be well dampened. A spray pump, sprinkler or old broom can be used for dampening the walls. The second coat of plaster can be applied immediately after the first, but in case more than two coats are to be put on, the first coat should set a few hours. Two coats are sufficient in heavy clay soil, but if the soil is sandy or gravelly, three to five coats should be used. The thicker the wall is plastered the nearer will the silo approach being everlasting. To save scaffolding and to avoid caving in of the walls before the pit is dug, it is best to plaster each section six feet deep before digging further. As soon as one section is plastered the next can be dug and plastered. It is not advisable to go more than twenty feet deep.

There are several good methods of removing silage from pit silos. For a small herd, and where the silo is near the place of feeding, a hand-over-hand pulley with a rope and two baskets is all that is necessary. Each basket should hold about enough silage for two cows. With a hook on each end of the pulley rope, one basket of silage can be raised while the empty basket is lowered. For a greater number of stock, a large box holding from 400 to 500 pounds of silage should be used. This must be raised by the use of block and tackle or windlass. The bottom of the box should open on hinges and let

the silage fall in a trough or wagon. An elevated track, such as a hayfork track, can be arranged to carry the silage to the feed troughs. With either of these methods it will require little more labor to feed from a pit silo. Figure 7 shows a hayfork track and tackle erected over the pit as in Figure 5, and run from there out over the feed troughs. Figure 8 shows how a barrel can be used for lifting the silage. The box with hinged bottom answers the same purpose. By using the horse fork rope the silage is elevated by horsepower instead of by manual labor. These arrangements can, of course, be used for taking the dirt out of the silo when digging, as well as the silage.

The pit silo affords a good opportunity for the small farmer with few cows to own a silo at little cost, as it is the only silo that a small size is not much more expensive per ton capacity than a large one. A pit silo of fifteen tons capacity costs no more per ton, if as much, as one that holds 100 tons.

Bank Silos

A bank silo is a pit silo constructed in the side of a hill or bank. The construction is the same as a pit silo on level ground except that

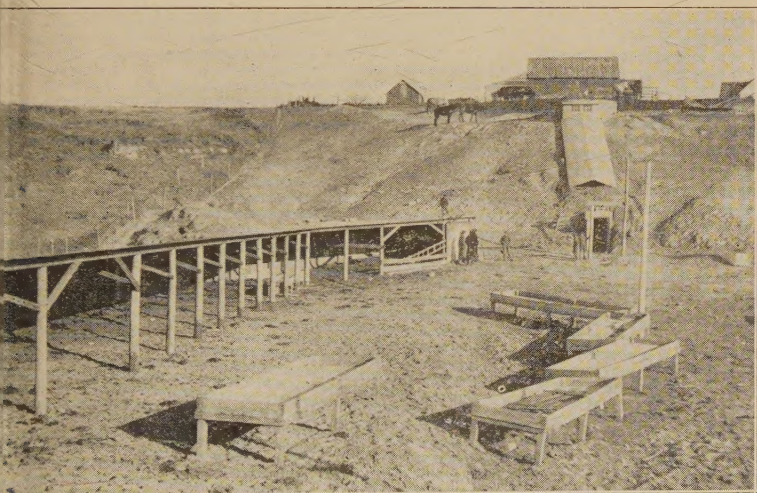


Figure 9—Bank silo. Feeding troughs and cattle sheds

has a continuous door, the same as the upright silo. Figure 9 shows one such silo in use at Holdrege, Nebraska. The entrance is boarded over and the silage is carried on overhead tracks to the feed troughs on the left. Figures 10, 11 and 12 show the best methods of building the doorway. The bank silo is plastered the same as a pit silo, but the doorway and adjacent walls are built with forms. Iron rods across the doorway serve as ladder rungs and strengthen the

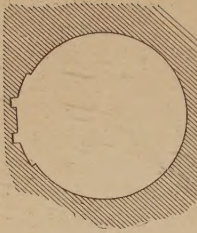


Figure 10

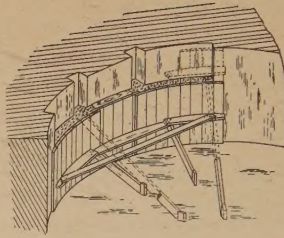


Figure 11

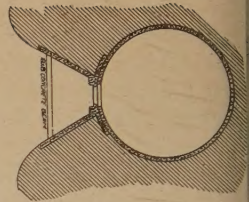


Figure 12

Figure 10 shows section of excavation for doorway of bank silo. Figure 11 shows forms in place for making concrete door frame. Figure 12 shows section of completed bank silo doorway. Wings held apart by concrete beam. (Courtesy of Nebraska Experiment Station)

concrete columns. The wings at each side of the passageway are braced by a concrete beam. The door frame can be made of 2x6's with cross pieces for a ladder and the walls of the passageway boarded up instead of being plastered. This arrangement is more or less temporary. The continuous door lessens the cost of digging in that the dirt may be removed at the side instead of at the top. When complete the bank silo is one of the most desirable silos, as it has all the good features of the ordinary pit silo and the silage is as easily removed as from any upright silo. However, there are few banks so conveniently located that they can be used for this purpose.

IV—THE HOMEMADE CONCRETE BLOCK SILO

Concrete block silos have been used for a number of years. They give good satisfaction and make very substantial structures if on good foundations, well reinforced and plastered inside. Where the cost of transportation of manufactured blocks is not too great, and where sand and stone have to be purchased anyway, it is doubtful whether there is any advantage in making blocks at home. If sand or gravel are close at hand, blocks may often be made very cheaply.

A cheap and very desirable type of block is made by the slush method in simple, homemade forms, using a sloppy mixture of cement and sand or cement and gravel. Make long troughs of 2-inch lumber 16 inches wide and 8 inches in depth. One side of these troughs is hinged or removable so that the blocks can be removed more easily. Clamps, bolts or other devices are needed to hold this side in place and to keep the sides from springing out when the form is filled. Sheet steel plates (16-gauge steel) 16½ inches by 8 inches, rolled to the curvature of the silo, are set in the trough as divisions. These plates are spaced in the trough by nailing blocks to the sides of the trough. Four-inch weatherboarding or lapping is used generally, as this makes about the right radial cut for the ends of the blocks, and makes a block four inches thick. This will make blocks 16x8x4, and ninety-one of these blocks can be made from one cubic yard of mixed con-

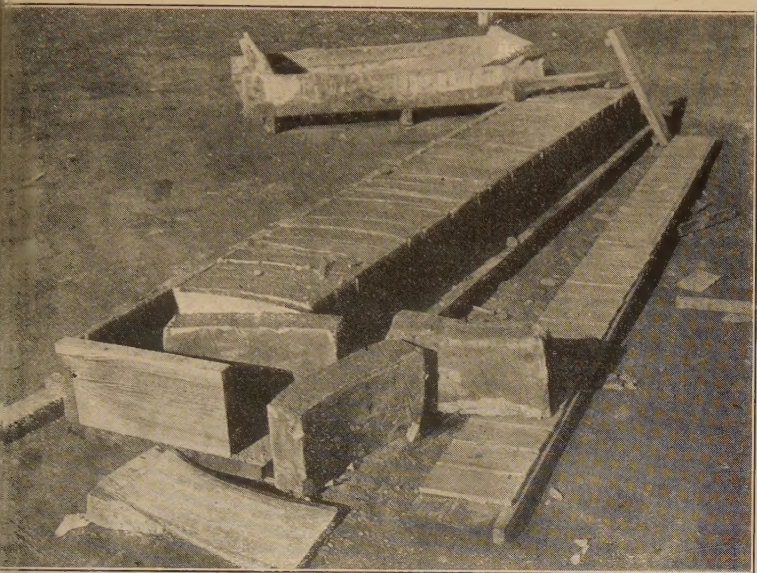


Figure 13—Mold for homemade concrete silo blocks 16x8x4 inches. One side of mold removed showing spacing blocks

crete (eight sacks cement and 1.1 yards sand or gravel). Sixteen hundred and thirty-two whole blocks and forty-eight half blocks are required for a 14x32 silo with continuous doorway. This equals eighteen and one-fourth yards concrete, or 146 sacks cement and twenty yards sand or gravel. (See Figure 13.) Blocks can be made five or six inches thick if desired.

One set of these plates may be used in a number of forms by adopting the following method: The plates are covered with wrapping paper and placed in the form. When the form is filled with the soft concrete the paper is cut along the edge of the dividing plates, the plates are then taken out and rewrapped and used in another form. To make a trench in the blocks to hold the reinforcing rods or wire, nail strips of one-half-inch or three-fourths-inch doorstop in the bottom of the forms. These strips should have the same curve as the division plates and be placed directly half way between the plates. It is not absolutely necessary to have these trenches in the blocks, but they will help in placing the reinforcement, especially where the blocks are being laid by unskilled labor. Soak the trough or oil it before filling.

This plan for making blocks was devised by Professor Davidson of Iowa and published in Bulletin No. 141 of that Station. Few silos have been constructed to date with these blocks, but the idea may be valuable to many. This concrete block mold has been proved practical in Iowa, and with enough forms a man can make hundreds of

blocks in a day. The blocks can be made on rainy days at half the cost of buying and transporting manufactured blocks, if the sand or gravel are cheap and close at hand.

A $\frac{3}{8}$ -inch iron rod should be placed between every layer of blocks until a point fourteen feet below the top of the silo is reached. After this a rod between every other layer of blocks is sufficient. The reinforcing around the door is important. If an intermittent door is desired, three or four layers of blocks are laid between each opening. The reinforcing rods at the doorway can be hooked around an upright right iron rod on each side. A steel or iron plate will be needed at the top of the door. A concrete rim might be made around the door with a two-inch offset for the door to go in. For a continuous door opening, use heavier rods and put in every other mortar joint letting them continue across the doorway.

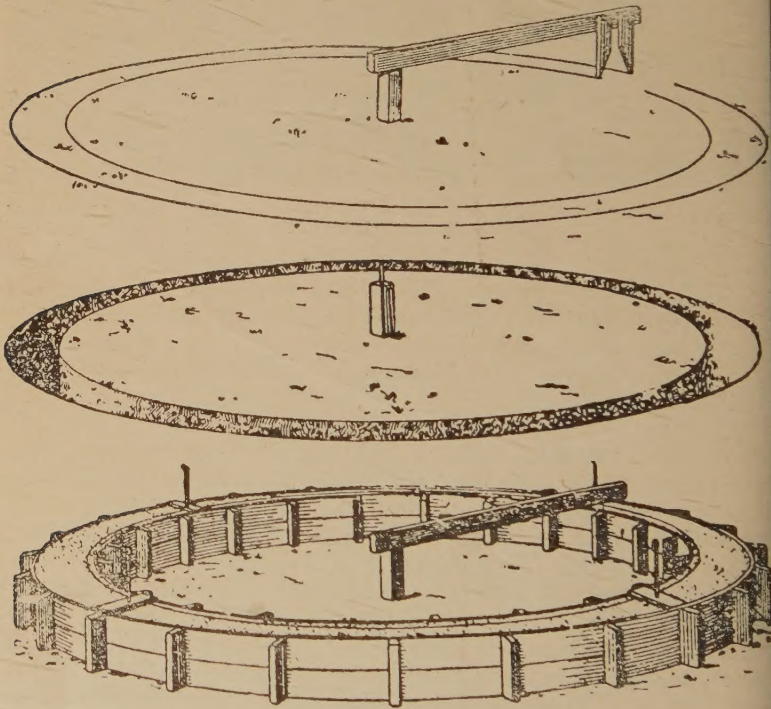


Figure 14 shows the best method of laying off the trench for the foundation of a silo or for the collar of a pit silo. Middle section shows trench dug. Lower section shows foundation forms in place and filled with concrete. The foundation is leveled by a spirit level on the same sweep used in describing the first circle

Foundation

Figure 14 shows the method used in laying off for a concrete foundation or for the rim of a pit silo, also the trench as dug and the foundation or rim completed.